DRAFT INTERNATIONAL STANDARD ISO/DIS 15863

ISO/TC **20**/SC **14** Secretariat: **ANSI**

Voting begins on **2002-05-30** Voting terminates on **2002-10-30**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Space systems — Launch-vehicle-to-spacecraft interface control document

Systèmes spatiaux — Document pour contrôle de l'interface entre le véhicule spatial et le lanceur spatial

ICS 49.140

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

ISO 15863 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard defines the basic rules for writing an Interface Control Document between Spacecraft and Launch Vehicle organizations. The necessity of writing this standard was expressed by the Communication Spacecraft Community, which is faced with an increasing number of launch vehicle Agencies, with the objective of reducing workload and costs.

The application of this standard will permit to control the compatibility of SC with various LV systems reducing thereby the risk of discovering incompatibilities late in the launch preparation process.

LV and SC organizations may include additional topics if required. Some sections of this document may refer to elements that are not applicable to the LV, SC or launch range characteristics, in which case they should be ignored. For most items, except when specified, the information can be provided in SC or LV drawings and in tabular or narrative format with figures.

Space systems — Launch-vehicle-to-spacecraft interface control document

1 Scope

The purpose of this standard is to provide Spacecraft (SC) and launch vehicle (LV) organizations with the general format for presenting the Interface Control Document (ICD) that verifies and controls the compatibility between SC and LV for a dedicated mission. This document shall address the definition of the mission, the compatibility of the SC with the LV environment, including all mechanical, electrical, radio frequency, and electromagnetic aspects related to SC to LV and SC to launch range interfaces, verification analyses and tests for the induced environment, and the necessary facilities and support for launch range operations.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 14303:2001, *Space systems – Spacecraft to launch vehicle interfaces.*

3 Applicable and reference documentation

3.1 Applicable documents

This section of the ICD shall provide the list of documents that are contractually binding and require a waiver or a formal agreement for any modification. This list shall include the applicable LV User's Manual.

3.2 Reference documents

This section of the ICD shall provide the list of documents that form the necessary database for the LV and the SC contractors in the course of the launch preparation. Typically, the list shall include the documentation related to the various analyses and test programs specific to the mission.

3.3 Safety Submission sheets

This section of the ICD shall provide the list of safety submission sheets and corresponding current status.

3.4 Waivers

This section of the ICD shall provide the list of applicable waivers and corresponding current status.

NOTE In case of conflict between the above listed documentation and the ICD, the latter shall take precedence.

4 Spacecraft mission characteristics

4.1 Mission description

This section of the ICD shall describe the purpose of the SC mission and its orbital characteristics. The section should include an in-orbit view of the SC and may address general aspects of the mission such as ground network, coverage zones and lifetime.

4.2 Spacecraft description

4.2.1 Spacecraft bus description

This section of the ICD shall describe the general characteristics of the SC bus including appendages. The following items may be addressed : platform type and heritage (if applicable), overall structure, fixed and deployable appendages, attitude and orbit control system.

4.2.2 Spacecraft payload description

This section of the ICD shall describe the payload equipment and its purpose. The following items may be addressed: antennas and associated frequency bands, transmission characteristics, transponder type and number, electrical power.

NOTE This chapter is optional for inclusion in this document. It is for reference and information only and does not establish interface definitions or requirements.

5 Mechanical interfaces

5.1 General

This chapter of the ICD shall provide the specific characteristics and parameters that establish the mechanical interface between the SC and the LV. The information can be provided in SC or LV drawings and in tabular or narrative format with figures.

5.2 Mechanical configuration

This section of the ICD shall describe LV and SC reference axes and relative rotational orientation including drawings of the SC and adapter assembly within the payload compartment, which show and define the location of all interface components.

5.3 Spacecraft fundamental frequencies

This section of the ICD shall state the minimum allowable SC fundamental frequencies in axial and lateral directions.

5.4 Usable volume

This section of the ICD shall provide drawings that show the allowable usable volume within the payload compartment. The usable volume is determined by the physical clearances that are based on the static clearances and dynamic deflections of the fairing and SC. The section shall also provide critical clearance information including detailed views of protrusion areas with associated dimensions.

5.5 Launch vehicle - Spacecraft adapter interface

This section of the ICD shall describe all characteristics of the physical and geometric interface for both the SC and the LV.

5.5.1 Payload adapter description (optional)

This section describe the general characteristics of the payload adapter considering the following items:

- Type
- Material
- Geometrical shape
- Diameter of upper and lower I/F rings
- Mass properties of equipped adapter

5.5.2 Interface ring characteristics

This section provides drawings showing side sections of the LV and SC interface rings with detailed dimensions and tolerances. The following characteristics shall be shown:

- Material
- Young's modulus
- Coating
  - Surfaces in contact
  - Other surfaces
- Roughness
- Flatness / Perpendicularity
- Stiffness
  - Applicable length
  - Section area
  - Inertia

This section shall also apply to a bolted interface between the LV and the SC adapter when the SC provides the adapter.

5.5.3 Separation system characteristics

This section provides drawings showing the separation system actuator mechanism. The following characteristics shall be included:

- Number
- Location
- Nominal stroke
- Reduced stroke
- Maximum force
- Energy per unit

5.5.4 SC mating system description

5.5.4.1 General

This section describes the SC mating and release system, including system characteristics and material properties as listed below. When the SC contractor provides the adapter, the corresponding separation shock spectrum at the LV-SC interface plane shall be shown (See Clause 9.2.7).

5.5.4.2 For a clampband system:

- Coating
  - Surface in contact with adapter and SC
  - Other surfaces
- Roughness
- Tension
  - Ground or test configuration
  - Flight configuration

5.5.4.3 For pyrotechnic bolts:

- Number
- Location
- Diameter
- Length
- Weight (of separated hardware)
- Pre-load

5.5.5 Mating system installation

This section defines the orientation of the mating system with respect to the adapter frame.

5.6 Connectors and microswitches

This section of the ICD defines the connector interface. The following characteristics shall be considered:

- Supplier and part number
- Quantity
- Location and mechanical I/F
  - Angular position
  - Radial position
  - Height from separation plane
- Push-on and push-off loads
- Energy released
- Separation force
- Keying index

5.7 Purges and fluid connection interface

This section of the ICD defines the SC purge and fluid connection interface. The following characteristics shall be considered:

- Location and mechanical I/F
  - Angular position
  - Radial position
  - Height from separation plane
- Push-on and push-off loads
- Energy released
- Separation force

5.8 Encapsulated spacecraft access

5.8.1 Spacecraft access requirements

This section of the ICD shall list SC items to be accessed and purpose of access needed, referenced to the SC coordinate system.

5.8.2 Access configuration

This section of the ICD shall provide information that shows the location and configuration of the required SC physical access openings in the payload compartment, including the following indications:

- Payload compartment relevant dimensions
- Location of center of door (s) referenced to the LV axes
- Dimensions of door(s)

6 Electrical interface

6.1 Umbilical wiring diagram

Provide detailed drawings of the SC to LV and SC to ground facilities wiring diagram.

6.2 Umbilical connectors

Organizations responsible for providing connector elements shall be identified.

Umbilical connectors shall be described for both the LV and the SC sides. The distinction shall be made between SC servicing and SC pyrotechnic functions that are maintained on separate LV-SC connectors. Example figures of connectors shall be included.

Connector characteristics shall be defined as follows:

- Supplier
- Part number
- Number of pins available to user
- Polarizing key orientation
- Insert clocking
- Location (see also Section 5.6)
- Backshell shielding requirement
- Harness shielding requirement

6.3 Umbilical wiring links

Umbilical links between the SC and the LV and between the SC and the electrical checkout equipment plugs shall be described with the following characteristic, for each connector and each connector pin:

- Pin number
- Function(s)
- Wire type
- Twisting and shielding

— Maximum voltage (Volts)

— Maximum current (Amps)

— End to end resistance (Ohms)

— Line start

— Line end

— Maximum voltage at separation (if applicable)

— Maximum current at separation (if applicable)

— Signal type

— Signal frequency

The LV Contractor shall define and conduct verification tests of the end to end, line to ground and line to line isolation resistance.

6.4 Electrical commands dedicated to spacecraft

6.4.1 Pyrotechnic commands

The SC contractor shall provide a schematic of the SC electrical circuits related to pyrotechnic commands. Pyrotechnic commands shall be described with the following characteristics:

— Command identification

— Number of redundant commands

— Time of command initiation

— Minimum time interval between commands (ms)

— Pulse width (ms)

— Voltage (Volts)

— Minimum all fire current (Amps)

— Maximum no fire current (Amps)

— Output isolation (Ohms)

— Wire gage

— Wire type

— Wire length from LV-SC interface

— Circuit connectors to pyrotechnic devices

— Initiator characteristics

The LV contractor shall indicate possible constraints applicable to the SC circuitry. In particular:

- SC wiring isolation requirements
- Safety plug definition

6.4.2 Dry loop commands

Dry loop commands shall be described with the following characteristics:

- Command identification
- Number of redundant commands
- Time of command initiation (on ground or in flight)
- Resistance ON/OFF (Ohms)
- Maximum, minimum & nominal voltage (Volts)
- Maximum current (Amps)
- On board circuit isolation
- Grounding requirements
- LV & SC circuit configuration

The LV contractor shall indicate possible constraints applicable to the SC circuitry. In particular:

- SC circuit protection requirements
- Safety plug definition

6.4.3 Electrical commands

Electrical commands generated by the LV for the SC shall be described with the following characteristics:

- Command identification
- Number of redundant commands
- Time of command initiation (on ground or in flight)
- Minimum time interval between commands (ms)
- Maximum, minimum & nominal output voltage (V)
- Maximum current (Amps)
- Current profile characteristics
- Command duration
- Grounding requirements
- Circuit configuration

The LV contractor shall indicate possible constraints applicable to the SC circuitry. In particular:

- SC circuit protection requirements
- SC wiring isolation requirements
- Safety plug definition
- Electromagnetic compatibility requirements

6.5 Separation status transmission

Indicate the measurement used to confirm SC separation.

6.6 In-flight telemetry

SC measurements transmitted via the LV telemetry system shall be characterized as follows:

- Number of channels
- Type of measurement
- Transducer range
- Signal voltage
- Sample rate
- Encoding format
- Source impedance (Ohms)

6.7 Power supply

The specification for electrical power provided by the LV to the SC, if required for pre-launch or flight phases shall be defined as follow:

- Voltage (V)
- Current (Amps)
- Time of transfer
- Frequency
- Ripple noise

The LV contractor shall indicate possible constraints applicable to the SC circuitry such as :

- SC circuit protection requirements
- SC wiring isolation requirements
- Electromagnetic compatibility requirements

6.8 Earth potential continuity

The SC requirements in terms of electrical continuity with respect to the Earth potential shall be expressed as follows :

- Location of reference point on SC
- Maximum resistance allowed between SC metallic elements and reference point
- Maximum resistance allowed for SC interface plane

7 Radio-frequency and electromagnetic interfaces

7.1 Characteristics of radio-electrical systems

7.1.1 LV radiofrequency characteristics

The description of the LV transmitter and receiver characteristics and of the ground radar transponders shall include the following information for each unit:

- Unit designation
- Function of unit
- Frequency band
- Carrier frequency
- Bandwidth corresponding to (-3dB) and (-60dB) attenuation
- Carrier modulation
  - Type
  - Index
- Carrier polarization
- Transmitter power (EIRP) : maximum value
- Field strength of receiver antenna : maximum value
- Antenna description
  - Location
  - Pattern & Gain

7.1.2 SC radio frequency characteristics

The description of the SC transmitter and receiver characteristics shall include the following information for each unit:

- Unit designation

- Function of unit
- Frequency band
- Carrier frequency
- Bandwidth corresponding to (-3dB) and (-60dB) attenuation
- Carrier modulation
  - Type
  - Index
  - Bit rate
  - Sub carrier frequency
- Carrier polarization
- Receiver frequencies
  - Local oscillator
  - First intermediate
  - Second intermediate (if applicable)
- Transmitter power (EIRP) : nominal and maximum values
- Field strength of receiver antenna : minimum, nominal and maximum values
- Antenna description
  - Location (with reference to SC drawings)
  - Pattern & Gain

7.1.3 SC transmission plan

The SC contractor shall provide the SC transmission plan. The status (ON/OFF) of each unit described in Section 7.1.2 shall be defined for the following typical phases :

- TBD hours before count-down sequence
- From start of count-down sequence until TBD* seconds after SC separation
- In transfer orbit
- On station

NOTE The LV contractor shall provide the list of events to be considered and the corresponding timetable.

7.2 RF Telemetry and command link

7.2.1 SC RF link definition

The SC radio frequency link requirements shall be defined by the SC contractor with the following indications :

- Number of sources and corresponding frequency bands
- Type of link requested (if several options are available)
- Purpose of link
- Link destinations
- Events corresponding to link activation and time-table

7.2.2 SC antenna coordinates

The location of SC antennae shall be described with the following indications for each antenna:

- Identification
- Coordinates in the SC reference frame
- Field of view

7.2.3 RF link implementation

If RF links are assured via a RF transparent window, the location of the window in the corresponding payload compartment shall be described by the following information:

- Relative position of SC RF components
- Reference axes of SC and of LV payload compartment with relative angular position
- Location of LV RF window and corresponding coordinates
- Dimensions of LV RF window

If RF links are assured via a passive standard repeater system, the location of the repeater in the corresponding payload compartment shall be described by the following information :

- Relative position of SC RF components
- Reference axes of SC and of LV payload compartment with relative angular position
- Location of LV repeater and corresponding coordinates

7.2.4 RF link budget

7.2.4.1 General

For SC data transmission using RF links during ground operations, the following link budget information shall be provided:

7.2.4.2 Telecommand

- At SC test equipment output
  - Frequency of signal
  - Bandwidth
  - Output power (max, nominal, min)
  - Modulation
- At SC omni antenna
  - Frequency of signal
  - Power density (max, nominal, min)

7.2.4.3 Telemetry

- At SC omni antenna
  - Frequency of signal
  - Bandwidth
  - Output power : EIRP (max, nominal, min)
- At SC test equipment input
  - Frequency of signal
  - Power density (max, nominal, min)

7.2.5 Base band signal characteristics

7.2.5.1 General

For SC data transmission using base band links during ground operations, the following base band signal characteristics shall be provided for the range system and the SC system :

7.2.5.2 Telemetry

- Number of channels
- Digital
  - Code
  - Bit rate
- Analog
  - Modulation
  - Frequency

— Acceptable input from SC (level and offset)

— Adjustable output to electrical support equipment (level and offset)

7.2.5.3 Telecommand

— Number of channels Digital

  — Code

  — Bit rate

— Analog

  — Modulation

  — Frequency

— Acceptable input from electrical support equipment (level and offset)

— Adjustable output to SC (level and offset)

8 Launch vehicle and spacecraft mission characteristics

8.1 SC input data for mission analyses

The SC contractor shall provide the input data defined in this chapter for all SC configurations associated with operations conducted by the LV contractor.

8.1.1 Reference axes

The LV and SC reference axes used for mission analysis studies shall be consistent with the mechanical configuration described in Section 5.2.

8.1.2 Mass and inertia characteristics

If the SC configuration changes before it is separated from the LV (deployment of antenna for instance), the following data shall also be given for the alternative configuration.

The mass of the SC with related tolerances shall be provided.

The center of gravity coordinates and related tolerances shall be given in a reference frame parallel to the SC reference frame with the origin located in the SC separation plane.

Moments and products of inertia and related tolerances shall be provided with respect to a reference frame parallel to the SC reference frame with the origin located at the SC center of gravity. Inertia ratios between the transverse moments of inertia and the longitudinal moment of inertia shall be indicated.

The products of inertia (P_{xy} , P_{yz} , $P_{zx)}$ are defined as follows :

$$P_{xy} = \int_m xy\, dm = - I_{xy}$$

$$P_{yz} = \int_m yz\, dm = - I_{yz}$$

$$P_{zx} = \int_m zx\, dm = - I_{zx}$$

where x, y, and z are the coordinates of the SC mass element *dm* expressed in the SC reference frame (translated at the SC center of gravity), I_{xy} , I_{yz} , and I_{zx} being the off-diagonal elements of the SC inertia matrix.

The SC static and dynamic unbalances and resulting tolerances compared with the LV specifications shall be provided.

8.1.3 Sloshing masses

Sloshing fluid masses shall be described for each tank by means of the following parameters:

- Type of tank (bladder, material, etc.)
- Type of propellant
- Maximum volume of tank
- Filled volume with fluid fill factor
- Mass of liquid
- Center of gravity of wet tank in SC reference frame

In case the mass of propellants is a significant fraction of the total SC mass, the LV contractor may require a pendulum model of the sloshing masses for attitude control analysis purpose.

For each tank, the pendulum model shall be defined for a one-g and a low-g gravity environment as follows:

- Mass (corresponding to sloshing fraction)
- Length
- Location of attachment point with respect to the tank
- First sloshing frequency (one-g model)

8.1.4 SC mission constraints

All SC mission characteristics that can affect the LV trajectory, the LV attitude or the sequence of flight events shall be indicated by the SC contractor, including but not limited to :

- Maximum allowable aerothermal flux at fairing jettisoning
- Solar aspect angle constraint after fairing jettisoning
- Telemetry data acquisition
- Limitations on angular accelerations or velocities
- Deployment of appendages before SC separation with related time sequence
- Use of inertial units before SC separation

8.2 Trajectory and performance analysis

8.2.1 Sequence of flight events (optional)

The LV contractor shall describe the various key flight events and corresponding times. Flight events include flight related LV commands before lift-off, the flight and separation of the various LV stages, and the payload(s) orientation and separation.

This data shall be derived and updated from the mission analysis studies (see Sections 8.2.2, 8.2.3 & 8.4.3)

8.2.2 Orbit

The target orbit derived from the mission analysis studies shall be described with the following set of typical parameters:

- Epoch: time of injection of the SC into target orbit
- Inclination (i) in degrees
- Altitude of perigee (H_p) in Km
- Altitude of apogee (H_a) in Km
- Argument of perigee (ω) in degrees
- Target longitude of descending node (Ω) with respect to the Greenwich meridian
- Target true anomaly (v) in degrees

NOTE 1 The above set of parameters is standard for elliptical orbits.

NOTE 2 For circular orbits, the semi-major axis (a) and the eccentricity (e) are generally used as alternatives to perigee and apogee altitudes.

NOTE 3 For escape orbits, the apogee altitude parameter (H_a) is replaced by the hyperbolic excess velocity squared (C_3) and the inclination by the declination of the departure asymptote

NOTE 4 For geostationary transfer orbit or similar type of orbits, the equivalent true altitude at first apogee passage shall be indicated.

NOTE 5 Any alternative set of orbit parameters can be provided upon agreement between the SC and LV contractors.

8.2.3 Injection accuracy

The LV injection accuracy resulting from the final mission analysis studies shall be described in terms of the orbital parameters as described above.

As minimal information, the standard deviations (1σ) of the orbital parameters will be given as listed below. As an option, a covariance matrix of the same parameters can be provided :

- Inclination (i) in degrees
- Altitude of perigee (H_p) in Km
- Altitude of apogee (H_a) in Km
- Argument of perigee (ω) in degrees

— Longitude of descending node (Ω) in degrees

NOTE 1 The above set of parameters is standard for elliptical orbits.

NOTE 2 For circular orbits, the semi-major axis (a) and the eccentricity (e) are generally used as an alternative to perigee and apogee altitudes as follows:

Δa in km

Δ(e sinω)

Δ(e cosω)

NOTE 3 For escape orbits, the apogee altitude parameter (H_a) is replaced by the hyperbolic excess velocity squared (C_3)

8.3 Launch windows

8.3.1 General

Launch windows shall be presented in tabular or graphical forms in U.T hours.

8.3.2 SC reference launch window (for multiple SC launches only)

The SC reference launch window shall be calculated by the SC contractor from the SC constraints (Clause 8.3.5) on the basis of a reference orbit associated with the standard dual launch window provided by the LV contractor.

The reference launch window shall be expressed in terms of a reference time and cover a period of one year.

NOTE The reference time is related to an orbital event such as the first perigee passage for instance

The LV contractor shall present the superimposition of the SC reference window and the LV standard window.

8.3.3 SC Final launch window

The SC final daily launch window shall be calculated by the SC contractor on the basis of the SC constraints (Section 8.3.5) with the actual orbit parameters (Section 8.2.2). The final launch window is expressed in terms of lift-off time and covers the foreseen launch period.

8.3.4 Combined launch window (for multiple SC launches only)

The LV contractor shall present the superimposition of the SC contractor final launch window and the copassenger launch window.

8.3.5 Launch window operational constraints (for multiple launches only)

The SC contractor shall describe the various sub-systems and operational constraints that are taken into account in the calculation of the SC launch window, including but not limited to :

— Solar aspect angle (SAA) with respect to one or two SC reference axes

  — In the separation attitude

  — In the apogee boost motor (ABM) firing attitude

— SAA with respect to sun sensors during Earth acquisition maneuvers and ABM firing

— Sun eclipse duration in transfer orbit

— Moon eclipse or interference of the moon with Earth sensors

— Ground station visibility and aspect angle (when the trajectory ground track depends on the launch time)

8.3.6 LV launch window capability

The LV shall specify the maximum LV launch window duration.

8.4 SC pointing and separation

8.4.1 Spin velocity

For spinning SC, the spin requirement shall be defined as follows:

— Spin velocity (RPM) and tolerance

— Spin axis with respect to the SC reference frame

— Spin direction (to be clearly shown in a figure)

8.4.2 SC attitude at separation

8.4.2.1 General

The LV contractor shall define an orbital reference frame so that required SC orientations at separation can be specified. The orbital frame orientation can be fixed with respect to the orbit plane or linked to the SC orbital position.

The SC contractor shall define the SC orientation just prior to separation in the following terms:

8.4.2.2 Spinning SC

— Components of the SC spin axis in the orbital reference frame

— Acceptable tolerance on the SC spin axis orientation

8.4.2.3 3-axis stabilized SC

— Components of the SC axes in the orbital reference frame

— Acceptable tolerances on the orientation of the SC axes

— Acceptable tolerances on the residual transverse velocities

When the SC separation attitude depends on the solar aspect, the corresponding constraints shall be expressed in the SC reference frame in such a way that the required attitude can be determined without ambiguity in the orbital reference frame as a function of the solar direction components.

The LV contractor shall indicate possible restrictions to the above requirements due to the LV attitude control system characteristics.

8.4.3 Orientation performance

8.4.3.1 General

The SC kinematic conditions immediately after separation resulting from the final pointing, separation and spacing analyses shall be indicated and compared with the LV specifications by the LV contractor in terms of mean value and standard deviation of the following parameters:

8.4.3.2 Spinning SC

- Spin velocity
- Transverse angular velocities
- Depointing of the SC angular momentum vector
- Relative separation velocity between SC and LV

8.4.3.3 3-axis stabilized SC

- Transverse angular velocities
- Depointing of all 3 SC axes
- Relative separation velocity between SC and LV

9 Verification analyses for induced environment

9.1 General

This Clause shall state either explicitly or by reference to applicable documents the results of the final verification analyses in order to assess the compatibility between the LV and the SC for the induced environment. A verification matrix can be used for this purpose.

9.2 Mechanical environment

9.2.1 Static acceleration

The static acceleration profile related to the LV flight shall be obtained from the trajectory analysis as described in Section 8.2.

9.2.2 Quasi-static loads

A synthesis of static and dynamic flight loads calculated at the SC center of gravity shall be provided on the basis of the dynamic coupled load analysis (processed with a test verified SC model).

9.2.3 Low frequency longitudinal vibration

The envelop of all longitudinal sine and transient vibrations at the SC base shall be provided in terms of equivalent longitudinal sinusoidal vibrations over the frequency range of interest.

9.2.4 Low frequency lateral vibration

The envelop of all lateral sine and transient vibrations at the SC base shall be provided in terms of equivalent lateral sinusoidal vibrations over the frequency range of interest.

9.2.5 Random Vibrations

The envelope spectrum of the flight level random vibrations in the longitudinal and lateral directions shall be provided.

9.2.6 Acoustic noise

The flight level noise spectrum under the payload compartment shall be provided in terms of octaves or third of octaves.

9.2.7 Shock

The envelope shock spectrum generated by the LV at the LV-SC interface plane shall be provided.

When the SC provides the adapter, the SC contractor shall provide the envelope shock spectrum generated by the SC separation system at the LV-SC interface plane.

9.2.8 Critical clearances

If applicable, the results of the dynamic clearance analysis of the SC critical points protruding outside the payload usable volume (Section 5.4) shall be provided.

9.3 Thermal environment

9.3.1 General

The detailed SC thermal environment related to the ground and flight phases is described in the LV-SC final verification coupled thermal analysis.

9.3.2 Air conditioning

A drawing showing the SC inside the payload compartment with a representation of the airflow path may be provided. The following payload compartment air conditioning parameters shall be indicated for the various operation phases:

— Inlet temperature

— Outlet temperature (optional)

— Relative humidity

— Filtration

— Air flow rate

— Air velocity

— Cleanliness

9.3.3 Aerothermal flux

The maximum aerothermal flux value shall be provided for the fairing jettisoning event and, if applicable, for any other high flux flight event with the corresponding phase duration.

9.4 Static pressure

The time history of the static pressure inside the payload compartment during the flight shall be provided.

9.5 Contamination and cleanliness

If applicable, the results of the contamination and cleanliness analysis conducted by the LV contractor shall be provided.

The SC contractor shall provide a list of the SC material outgassing characteristics.

9.6 Radio and electromagnetic environment

9.6.1 LV generated radiation

The LV contractor shall describe the radiation emitted at a specified LV station by the LV transmitters in terms of electrical field as a function of radio frequency bands.

9.6.2 SC generated radiation

The SC contractor shall describe the radiation emitted at a specified SC station by the SC transmitters in terms of electrical field as a function of radio frequency bands.

9.6.3 Range generated radiation

The LV contractor shall describe the range electromagnetic environment including telemetry, telecommand and radar transponders.

9.7 Overall compatibility

A conclusion on the compatibility between the LV and the SC with respect to the induced environment shall be formulated on the basis of the results presented in Sections 9.1 to 9.6.

10 Verification tests

10.1 General

The present chapter shall include either explicitly or by reference to applicable documents concise information to show the compliance of the SC test results with the corresponding LV requirements. A verification matrix can be used for this purpose.

10.2 SC mechanical environment qualification and acceptance tests

10.2.1 General

The SC contractor shall briefly describe the test philosophy adopted in order to verify the compliance of the SC design with the LV environment requirements as defined in the LV User's Manual.

The distinction shall be made between structural model (SM) used for qualification purpose, protoflight model (PFM) used for qualification and flight, and flight model (FM) submitted to acceptance tests only.

The list of tests applicable to the SC shall be indicated considering the following series of possible tests

— Static load

— Modal survey

— Sinusoidal vibration

— Acoustic noise

— Random vibration

— Separation shock

In the following, the test article and the test configuration shall be briefly described for each type of test, with the distinction between flight, flight-type and simulated hardware. The time and place of test, the test requirements and related conclusions shall be indicated.

10.2.2 Static load test

The maximum longitudinal and lateral loads shall be provided for the envelope test cases in comparison with the LV User's Manual quasi-static loads.

10.2.3 Modal survey test

The test results for the major SC structural modes shall be compared with the SC dynamic model data.

10.2.4 Sinusoidal vibration test

The SC unnotched base input profile shall be described and compared with the LV required levels. Preliminary notch parameters shall be agreed upon between the LV and the SC contractors on the basis of the SC design loads and LV-SC dynamic coupled load analysis results. Final notch parameters shall be established during testing.

10.2.5 Acoustic noise

The SC acoustic input levels shall be described and compared with the LV required levels.

10.2.6 Random vibrations

The SC random vibration input levels shall be described and compared with the LV required levels.

10.2.7 Separation shock test

The type of test and corresponding input spectrum shall be described and compared with the LV requirements.

10.3 Launch Vehicle - Spacecraft compatibility tests

The list of tests applicable to the SC shall be indicated considering the following series of possible tests :

— Match-mate

— Separation

— Umbilical connector pull-out

— Clearance measurement

— EMC

— End to end electrical

— RF link

11 Launch range operations: Facilities and support

11.1 Range capabilities

The LV contractor shall provide to the SC contractor a detailed documentation describing the overall facilities and support available for launch range operations. The present chapter shall mention only items specific to the SC launch campaign.

11.1.1 SC preparation facility

The LV contractor shall describe the facilities and equipment provided for processing the SC, including specific additional requirements from the SC contractor.

The following typical pieces of equipment or support may be listed for each relevant building hall when applicable:

— Access doors

  — Location

  — Size

— Crane characteristics

  — Capacity

  — Hook height

  — Range of vertical speed

— Electrical power supply

  — Voltage (V)

  — Frequency (Hz)

  — Maximum power (kVA)

  — Stability of frequency and voltage (%)

— Environment

  — Cleanliness class

  — Standard temperature (°C)

  — Standard relative humidity (%)

— Clothing (safety garments)

  — Location of use

  — Type of garment

- Type of protection
- Relevant hazardous operation requesting protection
- Availability

- Special technical support equipment

The floor space required and corresponding duration of time dedicated to the SC shall be identified for all relevant preparation areas, including:

- Preparation hall
- Check-out room
- Storage areas (and associate environment)
- Offices and meeting rooms

11.1.2 Solid propellant motor (SPM) preparation facilities (if applicable)

The LV Contractor shall describe the facilities and equipment provided for SPM preparation, including specific additional requirements from the SC contractor.

The following hazardous item storage facilities may be considered, including environmental conditions :

- SPM storage
- Pyrotechnics storage

11.1.3 X-ray facilities (if applicable)

The LV Contractor shall describe the facilities and equipment provided for SPM X-ray and final preparation operations, including specific additional requirements from the SC contractor.

The following specific items may be considered:

- X-ray equipment
- Turntable
- Film processing
- Cold soak

11.1.4 SC filling, control and final assembly facilities

The LV Contractor shall describe the facilities and equipment provided for SC filling, control and final assembly operations, including specific additional requirements from the SC contractor.

The following items may be considered, including hazardous item storage facilities :

- Weighing device
  - Scale
  - Load cells available

- Dynamic balance machine
  - Capacity (kg)
  - Spin rate (rpm)
  - Type of interface
- Liquid propellant storage and transfer
  - Type of liquid
  - Quantity
  - Period and duration of storage
  - Transfer conditions
- SC purge requirements
- SC fluid requirements

The LV contractor shall identify the floor space required and corresponding duration of time dedicated to the SC for all relevant SC filling, control and final assembly facilities, including:

- Filling hall
- Assembly hall
- Technical room
- Control room
- Storage areas (and associate environment)
- Offices and meeting rooms

11.1.5 Remote control facilities for hazardous operations (if applicable)

The LV Contractor shall describe the facilities and equipment provided for remote control operations, including specific additional requirements from the SC contractor.

11.1.6 Composite assembly facilities (if applicable)

Composite assembly facilities shall be used when SC, payload adapter(s) and payload enclosure are assembled together to form a composite structure to be mated with the LV.

The LV Contractor shall describe the facilities and equipment provided for composite assembly operations, including specific additional requirements from the SC contractor.

11.1.7 Launch preparation facilities

The mating between the LV and the SC or a pre-assembled composite is performed at the launch preparation facilities. This may be performed at the launch pad

The LV Contractor shall describe the facilities and equipment provided for launch preparation operations, including specific additional requirements from the SC contractor.

11.1.8 Payload handling and transport

The LV Contractor shall describe the facilities and equipment provided for payload handling and transport, including specific additional requirements from the SC contractor.

The following items shall be described:

- Payload to transport (SC, composite or other)
- Itinerary and timelines (optional)
- Type of transport or hoisting operations
- Transport or hoisting equipment
- Container for transportation
- Environmental conditions
- SC purge
- SC fluids

The SC Contractor shall indicate any specific instruction for handling and transport operations.

11.1.9 Mission control center

The LV Contractor shall describe the facilities and equipment provided for mission control operations, including specific additional requirements from the SC contractor.

11.2 Range communication facilities

11.2.1 External communications

The LV Contractor shall describe the external communication facilities to be provided. The SC contractor shall define the specific equipment to be provided by the SC.

The following items shall be considered:

- Type of lines (voice and data)
- Line distribution on the range

11.2.2 Range communication network

The LV Contractor shall describe the range communication network. The following items shall be considered :

- Operational intercom network
  - Point to point telephone network
- Range telephone network
  - Closed circuit television
  - Time reference

11.3 Umbilical lines and ground lines

11.3.1 Line description

The LV contractor shall describe the ground line and umbilical line facilities. The following items shall be considered:

— Network

— Type of lines (electrical characteristics)

— Purpose of network

— Applicable SC or LV-SC combined operations

11.3.2 Umbilical shielding and ground reference

The LV Contractor shall describe the ground and flight shielding grounding.

11.3.3 Rules for implementation of umbilical and ground lines

11.3.3.1 The LV Contractor shall indicate the rules and constraints to be met by the SC Contractor for the implementation of umbilical and ground lines. The following items shall be documented:

— Specific requirements (from SC Contractor)

— General drawing of umbilical wiring

— Rules for end to end checks

— Conformance Certificate (LV and SC contractors)

11.3.3.2 Responsibilities for equipment operating and test conducting shall be clearly established for the following operations:

— Installation of SC provided equipment

— Provisioning of connectors (SC side and ground side)

— Connecting to ground facilities

— Connection testing

— Check of configured network

— Modifications of configured network

11.4 Overall data transmission

11.4.1 Overall network description

The LV Contractor shall define the overall data transmission network of the range, including all operational types of transmissions. The following characteristics shall be indicated:

— Operations of interest

— Facilities connected

— Type of transmissions

— Connected items

— Line routing

11.4.2 Individual network

For each type of transmission network (RF, base-band, modem or other), the LV Contractor shall indicate the following:

— Connected facilities

— Limitations on transmission volume

— Physical interfaces (range side)

11.5 Operational constraints

The LV Contractor shall list the various operational constraints to be met by the SC contractor. The following typical items are given as examples:

— Safety regulation and implementation

— Security rules

— Launch campaign

— SC countdown operations : time windows

11.6 Range services

11.6.1 Safety facilities and Support

The LV Contractor shall describe the facilities and support related to safety, including :

— Training courses and briefings

— Role of range safety personnel

— Safety equipment available

11.6.2 Technical and general services

The LV Contractor shall provide a list of technical and general services available on the range, including for instance:

— Chemical analysis laboratory

— Mechanical and electrical workshop

— Optical and photographic workshop

— Measuring instruments laboratory

— General purpose services